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Image Transmission Using LDPC Log Domain Iterative Decoding Method

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Abstract: *Most source coding standards (voice, audio, image and video) use Variable-Length Codes (VLCs) for compression. However, the VLC decoder is very sensitive to transmission errors in the compressed bit-stream. Previous contributions, using a trellis description of the VLC codeword's to perform soft decoding, have been proposed. But the complexity of the trellis technique becomes intractable. In this paper, we propose a soft-input VLC decoding method which is not trellis based. Performance in the case of transmission over an Additive White Gaussian Noise (AWGN) channel is evaluated. Simulation results show that the proposed decoding algorithm exhibit very low complexity and also bit error rate (BER) at output of channel decoder decreases with increase in SNR. We consider the serial concatenation of a VLC with the channel code and perform iterative decoding. Results show that, when concatenated with Low Density Parity Check (LDPC) codes, iterative decoding provides remarkable error correction performance. Experimental results indicate that the proposed method requires less iteration and improves overall system performance.*

Keywords*: JPEG compression, Discrete Cosine Transform (DCT), Huffman encoding, LDPC codes.*

1. Introduction

The main aim of communication systems used for multimedia applications is to provide high quality of service while minimizing power and bandwidth consumption. Both source coding and channel coding are important components to achieve these goals. These two components can be optimized separately if unconstrained block lengths and unconstrained coding and decoding complexities are allowed. Previous works use separate source and channel coding/decoding which increase the delay of transmission and complexity of system. So Joint Source and Channel (JSC) coding/decoding system [5], [10] arise which decrease delay and complexity. Variable-Length Codes (VLCs) [2] are widely used in image, video and audio compression schemes. Although they provide a reduction in the data rate, the VLC encoded data are very sensitive to transmission errors. Especially when the compressed bit-stream has to be transmitted over a noisy channel, efficient coding or decoding techniques have to be considered to guarantee a good source-symbol sequence reconstruction.

In this paper we propose an iterative JSC decoding scheme based on a VLC concatenated with low-density parity check code (LDPC) channel code for image transmission application. The source/channel decoding is iterated several times to improve the error-rate performance. The VLC is used to perform source compression and the channel code performs error correction.

2. Proposed System

The proposed system is shown in Figure 1.Here input image is compressed using JPEG encoder which is then Huffman encoded for further compression and it is the source encoder. The Huffman encoded sequences are then applied to LDPC channel encoder which encode the sequences and this encoded sequences is modulated using BPSK modulation. This modulated sequence is then transmitted through an AWGN channel where noise is added .Finally this noise added sequences is then fed to the LDPC channel decoder for error correction and for decoding the reliable bits inorder to reconstruct the image transmitted. The LDPC decoded sequences is then Huffman decoded to retrieve the reliable pixel values and the image is reconstructed using the JPEG decoding scheme [1].

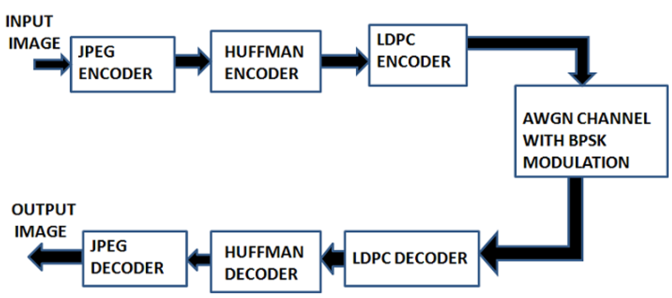


Figure 1. Proposed scheme for image transmission

Advantages of the proposed systems are

1. Reliability of bits can be provided.

2. Since LDPC decoder is used it decreases the complexity of system by taking the advantage of its decoding scheme.

3. Since iterative decoding is used the system can provide remarkable error correction with good quality of image reconstruction.

3. JPEG Compression

The general overview of JPEG process is [4], [7]

1. The image is broken into 8x8 block of pixels.

2. Working from left to right and from top to bottom DCT is applied to each block.

3. Each block is compressed through quantization.

4. The image is reconstructed through decompression using Inverse Discrete Cosine Transform.

3.1. Discrete Cosine Transform (DCT)

To get the matrix form of DCT use equation below where N=8

$$T_{ij} = \begin{cases} \frac{1}{\sqrt{N}} & \text{if } i = 0 \\ \sqrt{\frac{2}{N}} \cos\left[\frac{(2j+1)i\pi}{2N}\right] & \text{if } i > 0 \end{cases} \qquad (1)$$

For an 8x8 block it results in the matrix T which is given below. The pixel values of black and white image ranges from 0 to 255, where 0 represent pure black and 255 for pure white and grey is between them. But DCT is designed to work on pixel values ranging from -128 to 127 so the original image pixel block is “levelled off” by subtracting 128 from each entry which is given by equation(2).

M=original image (8x8 block)-128 (2)

DCT is performed by matrix multiplication i.e.

D=TMT’ (3)

In equation (3) the matrix M is first multiplied on left by DCT matrix T from previous section; this transforms the rows. The columns are then transformed by multiplying on the right by the transpose of the DCT matrix.

3.2 Quantization

The 8x8 block of DCT coefficients is compressed using quantization. A remarkable and highly useful feature of the JPEG process is that in this step, varying levels of image compression and quality are obtainable through selection of specific quantization matrices. This enables the user to decide on quality levels ranging from 1 to 100, where 1 gives the poorest image quality and highest compression, while 100 gives the best quality and lowest compression. As a result the quality/compression ratio can e tailored to suit different needs.

Subjective experiments involving the human visual system have resulted in the JPEG standard quantization matrix. With a quality level of 50, the matrix renders both high compression and excellent decompressed image quality if another level of quality and compression is desired; scalar multiples of the JPEG standard quantization matrix may be used. For a quality level greater than 50(less compression, higher image quality), the standard quantization matrix is multiplied by (100-quality level)/50.For quality level less than 50(more compression, lower image quality) the standard quantization matrix is multiplied by (50/quality level).This scaled quantization matrix which is the matrix D have range from 1 to 255.

Quantization is achieved by dividing each element in the transformed image matrix D by the corresponding element in the quantization matrix, and then rounding to the nearest integer value.

$$C_{ij} = \text{round}\left(\frac{D_{ij}}{Q_{ij}}\right) \qquad (4)$$

3.3. Decompression

Reconstruction of our image begins by decoding the bit stream representing the quantization matrix C. Each element of C is then multiplied by the corresponding element of the quantization matrix originally used as in equation. (5).

$$R_{ij} = Q_{ij} \times C_{ij} \qquad (5)$$

The IDCT is next applied to matrix R, which is rounded to the nearest integer. Finally, 128 is added to each element of that result, giving us the decompressed JPEG version N of our original 8x8 image block M.

N=round (T’RT) + 128 (6)

4. Huffman Encoding

Huffman coding [5] is used to code values statistically according to their probability of occurrence. Short code words are assigned to highly probable values and long code words to less probable values. Frequently occurring symbols are assigned short code words whereas rarely occurring symbols are assigned long code words. The resulting code string can be uniquely decoded to get the original output of the run length encoder. The code assignment procedure developed by Huffman is used to get the optimum code word assignment for a set of input symbols. The procedure for Huffman coding involves the pairing of symbols [3],[11]. The input symbols are written out in the order of decreasing probability. The symbol with the highest probability is written at the top, the least probability is written down last. The least two probabilities are then paired and added. A new probability list is then formed with one entry as the previously added pair. The least symbols in the new list are then paired. This process is continued till the list consists of only one probability value. The values”0” and”1” are arbitrarily assigned to each element in each of the lists. Huffman decoding is the reverse process.

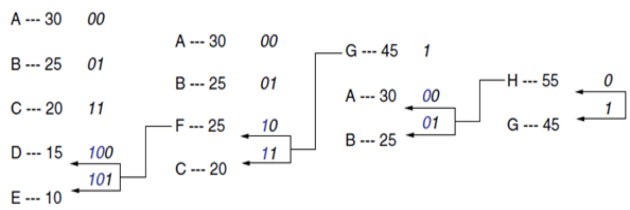


Figure 2. Huffman Coding Procedure

Figure 2. Shows the following symbols listed with a probability of occurrence where: A is 30%, B is 25%, C is 20%, D is 15%, and E = 10%.

1. Adding the two least probable symbols gives 25%. The new symbol is F

2. Adding the two least probable symbols gives 45%. The new symbol is G

3. Adding the two least probable symbols gives 55%. The new symbol is H

4. Write”0” and”1” on each branch of the summation arrows. These binary values are called branch binaries.

5. LDPC Codes

A binary (N, K) LDPC code [8] is a linear block code described by a sparse M x N parity-check matrix. A bipartite graph with M check nodes in one class and N symbol or variable nodes in the other can be created using H as its incidence matrix. Such a graph is known as the Tanner graph. An LDPC code is called (ds, dc) regular if in its bipartite graph, every symbol node is connected to ds check nodes, and every check node is connected to dc symbol nodes; otherwise, it is called an irregular LDPC code. The graphical representation of LDPC codes is attractive, because it not only helps understand their parity-check structure, but, more importantly, also facilitates a powerful decoding approach [4], [9].

5.1 Tanner Graph Representation

Tanner Graphs are pictorial ways of representing the parity check matrix of block codes. They can represent the H matrices of LDPC code. The rows of a parity check matrix [6] are represented by the check nodes, while the columns are represented by variable nodes. An example of parity check matrix is shown in Figure 3. If there is a 1 at a given position (j,i), where j is the row index and i is the column index, an edge is used to show this connection in the Tanner graph. Figure 4. Illustrates a Tanner graph implementation for the H matrix.

5.2. LDPC Log Domain Sum Product Algorithm (SPA) Decoder

In log domain decoding logarithm is taken which include addition rather than multiplications [12]. To do so we first define the LLRs are

$$L(c_i) = \log\left(\frac{Pr(c_i=0/y_i)}{Pr(c_i=1/y_i)}\right) \quad (7)$$

$$L(r_{ij}) = \log\left(\frac{r_{ij}\,(0)}{r_{ij}\,(1)}\right) \quad (8)$$

$$L(q_{ij}) = \log\left(\frac{q_{ij}\,(0)}{q_{ij}\,(1)}\right) \quad (9)$$

$$L(Q_i) = \log\left(\frac{Q_i\,(0)}{Q_i\,(1)}\right) \quad (10)$$

Where q_{ji} is message from variable node to check node and r_{ji} is form variable to check node.For AWGN channel

$$L(q_{ij}) = L(c_i) = 2y_i/\sigma^2 \quad (11)$$

5.2.1. Check node processing

It is the message passed from the check node f to variable node c in Figure 4.It includes first factor $L(q_{ji})$ into its sign and magnitude.

$$L(q_{ij}) = (\alpha_{ij}.\beta_{ij}) \quad (12)$$

$$\alpha_{ij}=\text{sign}\,(L(q_{ij})) \quad (13)$$

$$\beta_{ij}=|(Lq_{ij}| \quad (14)$$

$$L(r_{ij})= \prod_{i'\epsilon vj\backslash i} \alpha_{i'j}.\emptyset\left(\sum_{i'\epsilon vj\backslash i} \emptyset(\beta_{i'j})\right) \quad (15)$$

Where $\emptyset(x) = \log[(e^x+1)/(e^x-1)]$ (16)

5.2.2. Variable node processing

It is the message passed from the variable node c to check node f as in Figure 4.It includes first find

$$L(q_{ij})= L(c_i)+\left(\sum_{j'\epsilon ci\backslash j} L(r_{j'i})\right) \quad (17)$$

$$L(Q_i)= L(c_i)+\left(\sum_{j\epsilon ci} L(r_{ji})\right) \quad (18)$$

$$H = \begin{bmatrix} 1 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 & 1 \end{bmatrix} \begin{matrix} f_0 \\ f_1 \\ f_2 \end{matrix}$$

$$\begin{matrix} c_0 & c_1 & c_2 & c_3 & c_4 & c_5 & c_6 \end{matrix}$$

Figure 3. Parity check matrix example.

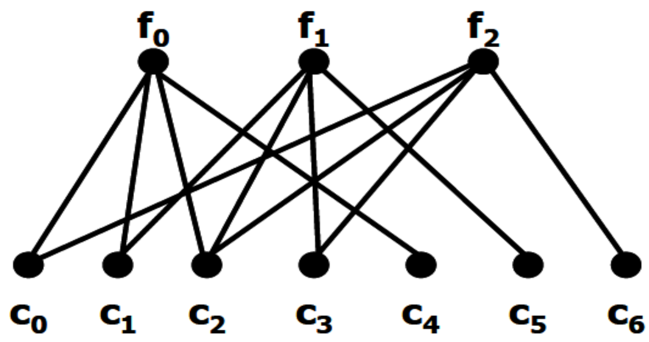


Figure 4.Tanner Graph representation

5.2.3. Steps of Decoding

1. For i=0,1……..n-1 initialize $L(q_{ij})$ using equation(11) for all i,j for which h_{ij}=1.

2. Update $L(r_{ij})$ using equation (15)

3. Update $L(q_{ij})$ using equation (17)

4. Update $L(Q_i)$ using equation (18)

5. .For i=0, 1……..n-1,

set $c_i\hat{}=\begin{cases} 1 \; if \; L(Q_i) < 0 \\ 0 \quad elsewhere \end{cases}$ (19)

6. If c^.H^T =0 or the number of iterations equals the maximum limit, stop; else go to step 2.

6. Results and Discussions

The platform used is MATLAB and output is shown in Graphical User Interface (GUI) .Here there is a simulate button and using this image is selected from the corresponding folder. Using GUI interface there are different panels for showing output. The flow of output is select Input image, Huffman VLC encoder, Channel encoder with BPSK modulation, Channel decoder, Huffman VLC decoder, Output image.

The implemented LDPC based image transmission using MATLAB is shown in Figure 5. The input image as in panel(1) used here is Lena which is 80x80 in size and is compressed using JPEG compression scheme where the quality level used here is 40.The pixel values are compressed through quantization process. The quantized values are assigned with probability values and are encoded using Huffman encoding whose output is sequence

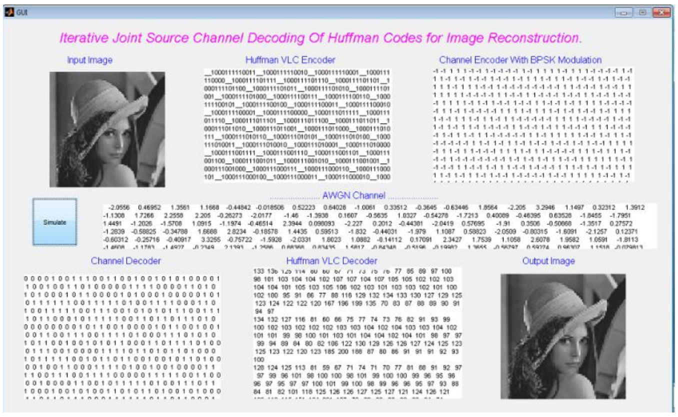
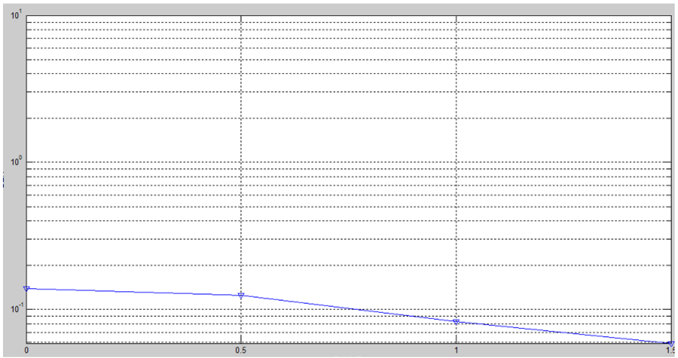


Figure 5. LDPC based image transmission using MATLAB.

BER



SNR

Figure 6. Bit Error Rate (BER) vs. SNR plot of LDPC

This Huffman encoded sequence is then given to LDPC channel encoder where the parity matrix generated by LDPC encoder is multiplied with the Huffman encoded sequence which is then modulated using BPSK modulation where all logic ones in the decoder.sequence are represented by +1V and all logic zeroes in the sequence are represented by -1V and is shown in panel (3). Then the modulated sequences are transmitted through AWGN channel where noise variance is added with the modulated sequence and is transmitted through the channel and is shown in panel (4).This transmitted sequence is then decoded using LDPC channel decoder whose values are sequences of 1s and 0s and is shown in panel (5).The LDPC decoded output is then further decompressed using Huffman decoder where the probability values are retrieved and the pixel values are retrieved using JPEG source decoder and is shown in panel (6) which will reconstruct the transmitted image and is shown in panel (7). The BER vs. SNR plot of LDPC decoder is given in fig (5) where as the SNR increases the BER decreases .

7. Conclusion

From the experimental results, it is clear that the proposed joint iterative decoding method can improve overall system performance. Here we perform the image transmission through AWGN channel using BPSK modulation scheme. A low complexity LDPC based channel decoding is used. Using LDPC decoder reliability of the decoded bits as well as good error correction performance can be achieved. It is also achieved that the LDPC channel decoder BER decreases as the SNR increases.

The future work is to add encryption and decryption algorithms in order to provide security of the image transmitted.

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References

[1] Amin Zribi, Ramesh Pyndiah, Sonia Zaibi, Frédéric Guilloud,and Ammar Bouallègue,"Low-Complexity Soft Decoding of Huffman Codes and Iterative Joint Source Channel Decoding," IEEE Trans. Comm., vol. 60, no. 6, June 2012

[2] Ragnar Thobaben and Jrg Kliewer ," An Efficient Variable-Length Code Construction for Iterative Source-Channel Decoding," IEEE Trans. Comm, vol. 57, no. 7, July. 2009.

[3] D. A. Huffman, "A method for the construction of minimum redundancy Codes," Proc. I.R.E., vol. 40, no. 9, pp. 1098–1102, Sep. 1952.

[4] L. Pu, Z.Wu, A. Bilgin, M.W. Marcellin, and B. Vasic,"LDPC-based iterative joint source channel decoding for JPEG2000," IEEE Trans. Image Process., vol. 16, no. 2, Feb. 2007.

[5] Mridul Kumar Mathur, Seema Loonker, Dr. Dheeraj Saxena," Lossless Huffman coding technique for image compression and reconstruction using binary trees"Int.J.Comp.Tech.Appl, Vol 3 (1), 76-79.

[6] David J. C. MacKay," Good Error-Correcting Codes Based on Very Sparse Matrices", IEEE Trans. . . . Inf.Theory, Vol. 45, no. 2, March 1999

[7] Andrew B. Watson, "Image Compression Using the Discrete Cosine Transform," Mathematica Journal, Vol. 4, No.1, Pp.81-88, 1994.

[8] K. Lakovic, Tao Tian, and J. Villasenor, "Iterative decoder design for joint source-channel LDPC coding," in Proc. 2005 EUROCON Int.Conf. Computer as a Tool.

[9] R. G. Gallager, "Low-density parity check codes," IRE Trans. Inf.Theory, vol. 8, pp. 21–28, Jan. 1962.

[10] V. B. Balakirsky, "Joint source-channel coding with variable length codes," in Proc. 1997 IEEE Int. Symp. Inf. Theory, p. 419.

[11] Mamta Sharma," Compression Using Huffman Coding", IJCSNS International Journal of Computer Science and Network Security, VOL.10 No.5, May 2010.

[12] William E.Ryan," An introduction to LDPC codes", Dept. of electrical and communication Engg. The university of Arizona, Box ,August 2003.

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