LDPC DECODER FOR TEXT AND IMAGE USING HARD AND SOFT THRESHOLD METHODS

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Abstract: The linear error correcting code - Low Density Parity Check (LDPC) code is used to reduce the errors that occur in the noisy communication path. These codes are forward error correction codes and hence data rate is more. The proposed work involves implementation of LDPC decoder using both soft decision and hard decision methods for text data. Further, the proposed work is extended for image coding and decoding. This process involves conversion of gray image to binary using threshold operation. The obtained binary image is LDPC encoded and decoded using both hard and soft decision methods. Result shows that LDPC codes provides lower bit error rate (BER) for efficient data decoding and hence LDPC codes are finding increasing use in applications requiring reliable and highly efficient information transfer over noisy channels. These codes are capable of performing close to the shannon's capacity. In this project LDPC encoder and decoder architecture for 8-bit message vector is analyzed and designed using MATLAB code. Although an LDPC code is a block code it gives an exceptional BER performance nearly close to Shannon limit when compared to other block codes. This is due to the message passing decoding algorithm used in the LDPC decoder. LDPC codes also provide high code gain at low BER.

Index Terms - **LDPC, Tanner Graph, Hard decision decoding, Soft decision decoding.**

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I. INTRODUCTION

LDPC codes are one of the most important topics in coding hypothesis today. Initially found in the mid 1960's, they have encountered an astounding comeback over the most recent couple of years. Not at all like numerous different classes of codes, LDPC codes are now outfitted with quick (probabilistic) encoding and decoding. New logical and combinatorial tools make it conceivable to take care of the outline issue. This makes LDPC codes not just important from a hypothetical perspective, yet additionally ideal for down to earth applications[1].

A communication is said to be perfect if and just if the transmitted information is gotten at the recipient end with no mistake. At the point when the information is transmitted over a communication channel there is an opportunity to happen a mistake because of the noise presence in the channel [2]. The principle challenge in the communication framework is to accomplish a dependable and a error free transmission of information from data source to sink. To build the dependability of information transmission, two essential error control techniques are utilized [3]. They are Automatic Repeat Request (ARQ) and Forward error correction (FEC) [4].

The idea of channel coding was presented by Claude Shannon in his original paper in 1948 [5]. In that he presented another channel parameter known as channel limit. Shannon hypothesis demonstrated that "In an noisy channel with limit C a data is transmitted at a rate R at that point, if R is not as much as C there exist a coding strategy which permits the likelihood of blunder(error) at the receiver to be made subjectively small" [6]. Frequently used block codes are Turbo codes, Hamming codes, BCH codes, RS codes and LDPC codes [7]. The complexity codes are preferred to use for error correction at real time and translate a whole data stream into single code word. Even though an LDPC is a block code give an extraordinary BER performance almost close to Shannon threshold when match up to previous block codes. This happens because of message passing decoding algorithm performed in the LDPC decoder [8].

II. OVERVIEW

One of the linear block codes is LDPC where sparse property followed for parity check matrix. The error correcting code Low Density parity check (LDPC) which is used to reduce the fault in the noisy communication path and chance of information loss. This possibility can be minimized to a required value so that the transmission of data rate can get closer to Shannon's threshold [9].

2.1 Irregular LDPC codes

The set of nodes degree will be considered based on some proper distribution in irregular LDPC. The primary step used to describe the required number of column and rows for every weight. Further step concentrated on construction method which consists an algorithm to find out edges in between vertices where some constraints to be followed [11].

2.2 Tanner Graph

Two different types of LDPC representation are H matrix and graphical form. Tanner who was introduced the graphical form of representation for LDPC are called tanner graph. This is bipartite graph where its get separated into two parts like digital nodes and sub code nodes, check nodes and variable nodes, check nodes and message nodes[12]. The tanner graph for matrix representation is given below.
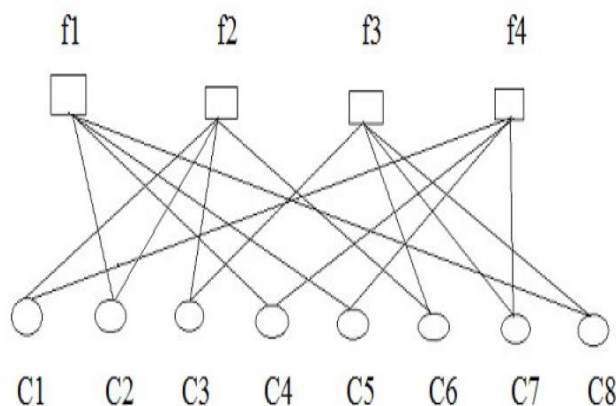
Figure 1: Tanner Graph

Where C1, C2, C3, C4, C5, C6, C7, C8 are variable nodes.

f1, f2, f3, f4 are check nodes.

III. RELATED WORKS

Low-density parity-check (LDPC) codes [1] can, for large block size, achieve a performance very close to the Shannon limit [2], with low-complexity iterative decoding by Believe Propagation (BP) or the Sum-Product Algorithm (SPA) [3]. Decoding of LDPC codes can be performed efficiently as long as the parity-check matrices are sparsely populated with which is the length of the shortest cycle in the Tanner graph [4] of the code, determines the performance under BP decoding. The parseness of the parity-check matrix (PCM) allows for decoding with low complexity based on a graph based decoder.

However, encoding with low complexity is not straightforward, as LDPC codes are defined by their PCM and the generator matrix is generally unknown. The conventional way is systematic encoding [3] with the generator matrix derived from PCM by (modulo-2) Gaussian elimination. The method is the same for any block code, thus it does not deploy the sparseness of LDPC codes, and the complexity is O(n2) (Pre processing O(n3), actual encoding by matrix multiplication O(n2)) where n is the length of the code words; for large block size n the encoding complexity can be significant.

Some novel ideas for lower-complexity LDPC encoding where the spaseness of PCM is exploited have been presented recent years: the graph-based message-passing encoder [5], [6] is a technique that uses the decoder for encoding by assuming that the unknown parity bits have been erased by the channel. Hence, the encoding process is exactly the same as decoding after transmission over a binary erasure channel (BEC). The idea applies to any LDPC code regular or irregular, random or structured. The method, however, does not always work, in particular when stopping sets [7] exist within the code.

As the demand for video streaming services is constantly growing day by day which has motivated us to analyze and design algorithm to provide good error probability. The available bandwidth on mobile is limited and expensive thus we need some technology that utilizes the available spec1rum more efficiently and providing good error correction capability. The implementation presented here is based on iterative decoding using belief propagation. The algorithm propagates soft probabilities of the bits between bit nodes and check nodes through the Tanner graph, there by refining the confidence that the parity checks provide about the bits. A Tanner graph is a bipartite graph introduced to graphically represent codes. It consists of nodes and edges. The nodes are grouped into two sets. One set consists of n bit nodes and the other of m check nodes. The exchange of the soft probabilities is termed as belief propagation. The iterative soft-decision decoding of code converges to true optimum decoding if the tanner graph contains no cycles. Therefore, we want LDPC code with as few cycles as possible. An LDPC code is a linear block code defined by a very sparse parity check matrix, which is populated primarily with zeros and sparsely with ones. The LDPC code also showed improved performance when extended to non-binary code as well as binary code to define code words. The LDPC code yields a signal to noise ratio approaching a Shannon channel capacity limit, which is the theoretical maximum amount of digital data that can be transmitted in a given bandwidth in presence of certain noise interference.

IV. PROBLEM DEFINITION

A communication is said to be perfect if and only if the transmitted data is received at the receiver end without any error. When the data is transmitted over a communication channel there is a chance to occur an error due to the presence of noise in the channel. The main challenge in the communication system is to achieve a reliable and an error free transmission of data from information source to destination.

V. PROPOSED SYSTEM

Figure 2 shows the system model uses LDPC code for basic digital communication system as the channel code. Let LDPC encoder takes input *u* such as block of message bits and LDPC encoder gives output as v. The codeword C will get following BPSK modulation. Through the communication channel the C codeword is get transmitted to corresponding receiver. Channel is represented as AWGN by means of noise power density *No/*2.The Noisy AWGN channel to be used to transmit the data and to act a communication gateway. There is a possibility of added up noise with signal. The end product may be of having error in data gets transmitted.
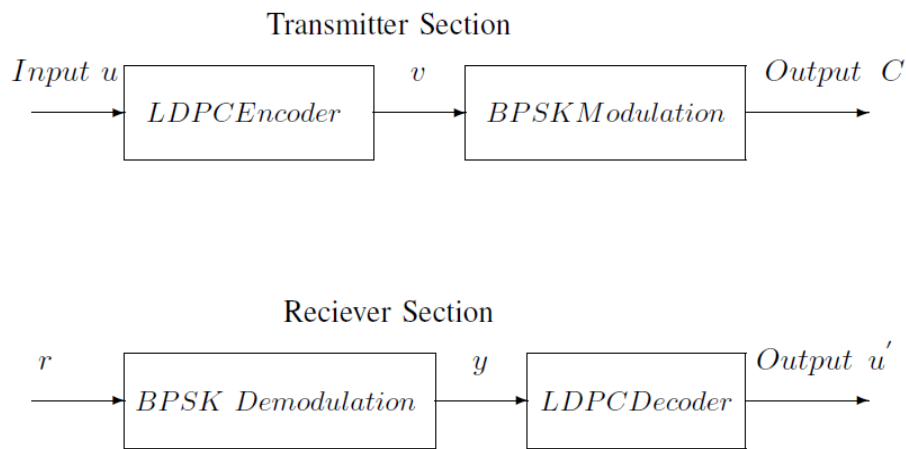
Transmitter Section

$Input\ u$ → LDPCEncoder → v → BPSKModulation → $Output\ C$

Reciever Section

r → BPSK Demodulation → y → LDPCDecoder → $Output\ u'$

***Fig 2:* Block Diagram of System Model Using LDPC Codes**

The BPSK demodulator gets 'r' received codeword as a part of input to reverse the modulation carried out at transmission part. Further demodulated codeword y is accepted during the LDPC decoder and the approximation of original message *u* is get back at the LDPC decoder. it cross the threshold value then encryption will take place else the file uploaded without encryption. Fig.2 shows the process in detail.

VI. METHODOLOGY

The iteration process followed to perform the LDPC decoding on the basis of tanner graph in order to give assurance on parity check conditions. The base condition is CHT=0 is called parity check condition. Suppose CHT=0 said to be the received codeword is valid and its almost same as transmitted codeword. Iterative process of decoding follows two variants knows as soft decision and hard decision decoding.

6.1 Hard decision decoding

The best example for hard decision decoding is Bit flipping algorithm. The message and edges present in tanner graph are accepted as one in bit flipping algorithm. The message nodes are used to send messages to communicate data that the bits obtainable at the message node are zero or one to check node [13]. The message node receives updated message or response from the check node. The Figure 1 indicates the tanner graph and it's used for decoding algorithm.

Step 1: Check nodes will get received message from all connected message nodes.
Step 2: For all received messages to every check nodes will calculate response to its message nodes which are gets connected. The parity check equation is used to calculate a response. Go to step3.
Step 3: The check node response to be used to decide bit position is 1 or 0 by majority rule. This hard decision has been sent by message nodes to its linked check nodes.
**Step 4:** Step 2 repeats until its get exit or a allotted number of iterations completed.

6.2 Soft decision decoding

Soft decision decoding took up by the idea of belief propagation. The sum-product algorithm is execute well on some classes of graphs exist with cycles. This algorithm plays a major role in coding application and till today it is having some huge scope due to its working level. It grabs attention for researchers, because of some application in the area of physics, optimization and artificial intelligence.

Soft decision message passing algorithm is sum-product decoding algorithm. The log-likelihood ratios are used to express the probabilities in sum product decoding. LLR (Log Likelihood ratios) usually meant apri matrix representation for binary variable with single value. The bit-flipping looks similar to sum-product algorithm. The common dissimilarity in between bit flipping and SPA is every decision to be given by data bits probabilities.

VII. RESULTS AND DISCUSSIONS

The proposed work involves implementation of LDPC decoder using both soft decision and hard decision methods. The Fig 3 shows the comparison of bit error rate (BER) for both the methods. It is clear that the soft decision method yields less error rate when compare to hard decision technique.
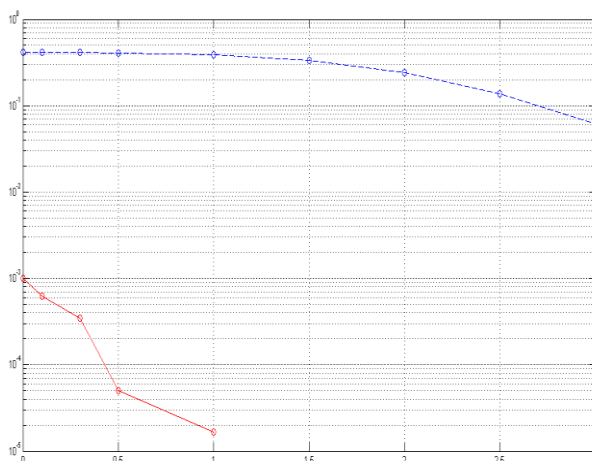
Figure 3: BER Comparison of Soft and Hard Methods

Further, the proposed work is extended for image coding and decoding. This process involves conversion of gray image to binary using threshold operation. The obtained binary image is LDPC encoded and Decoded using both hard and soft decision methods. Fig 4 shows the results obtained for image after applying soft and hard decoding techniques.
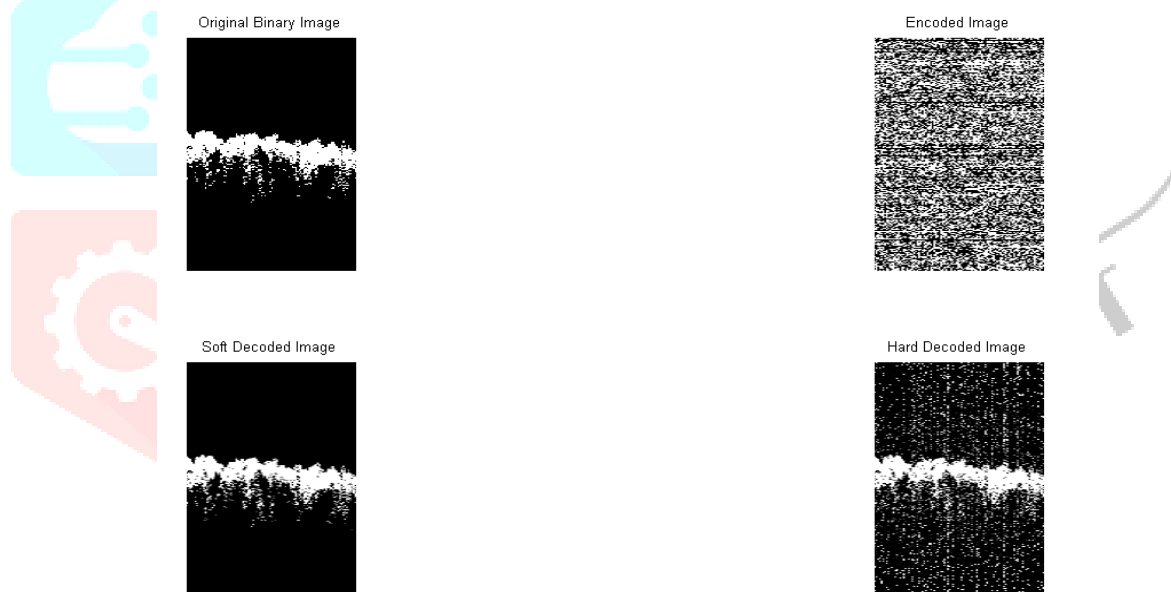
Figure 4: LDPC Decoder applied for Image

VIII. CONCLUSION

The useful FEC code to perform error correction is LDPC. The decoding algorithm selection and chosen design can give more credibility for LDPC. The performance evaluated in terms of bit error rate for soft decision decoding by log domain with hard decision decoding algorithm. The various code rates and SNR levels are used to perform the actual comparison. The best BER performance to be achieved in soft decision decoding algorithm compared to hard decision decoding algorithm in spite of SNR level. But both gives good performance in terms of bit error rate at lower code rates compared to high rates.

REFERENCES

[1] Michel Zorzi, *Performance of FEC and ARQ Error Control IN Bursty Channel Under Delay Constraints*, VTC'98, OTTAWA Canada May 18-21, 1998.

[2] C. E Shannon, *A Mathematical Theory of Communications*, Bell Systems Technology Journal, pages 379-423, 623-657, 1948.

[3] R. G Gallager, *Low Density Parity Check Codes*, IRE Transactions on Information Theory, vol-8. no.1, pp21-28, January 1962.

[4] Aqiel N. Almaamory, Husam Abduldaem Mohammed, *Performance Evaluation and Comparison Between LDPC and Turbo Coded MCCDMA*, Journal of Engineering, vol. 18, no. 8, April 2012., 2nd ed., January 2002.

[5] B. Vasic , Ivan B. Djordjevic, *Low density parity check code and iterative decoding for long haul optical communication system*, Journal of light wave technology , vol.21.no.2. February 2003.

[6] M. M Jadhav, Ankit Pancholi, Dr. A. M Sapkal, *Analysis and Implementation of Soft Decision Decoding Algorithm of LDPC*,International Journal of Engineering Trend and T Michel Zorzi, Performance of FEC and ARQ Error Control IN Bursty Channel Under Delay Constraints, VTC'98, OTTAWA Canada May 18-21, 1998.

[7] R. G. Gallager, Low Density Parity-Check Codes. MIT Press, Cambridge, MA, 1963.

[8] M. Luby, M. Mitzenmacher, and A. Shokrollahi, Analysis of random processes via and-or tree evaluation," in Proceedings of the 9th Annual ACM-SIAM Symposium on Discrete Algorithms, pp. 364{373, 1998.

[9] M. Luby, M. Mitzenmacher, A. Shokrollahi, and D. Spielman, \Analysis of low density codes and improved designs using irregular graphs," IEEE Trans. Inform. Theory, vol. 47, pp. 585{598, 2001.

[10] T. Richardson and R. Urbanke, \The capacity of low-density parity check codes under message- passing decoding," IEEE Trans. Inform. Theory, vol. 47, pp. 599{618, 2001.

[11] T. J Richardson, M. A Shokrollohi and R. L Urbanke, *Design of Capacity Approaching Irregular Low Density Parity Check Codes*, IEEE Trans. Inform. Theory, Vol. 47, no 2, pp 619-637, Feb 2001

[12] R. M Tanner, *A Recursive Approach to Low Complexity Codes*, IEEE Transaction on Information Theory, IT-27(5):533-547, Sep 1981.

[13] Namrata P. Bhavsar, Brijesh Vala, *Design of Hard and Soft Decision Decoding Algorithms of LDPC*, International Journal of Computer Applications (0975 8887) Volume 90 No 16, March 2014.

[14] Lakshmi.R, Tilty Tony, Abin Johns Raju, *An Analytical Approach to The Performance of Low Density Parity Check Codes*, International Conference on Advanced Computing and Communication Systems (ICACCS -2013), Dec. 19 21, 2013

[15] Vikram Arkalgud Chandrasetty, Syed Mahfuzul Aziz, *FPGA Implementation of a LDPC Decoder using a Reduced Complexity Message Passing Algorithm* , Journal of Networks, Vol. 6, no. 1, January 2011