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Modified decoding algorithm of Low density parity check code using BPSK modulation

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ABTRACT:
Low-density parity-check (LDPC) codes belongs to class of linear block codes. The presently used LDPC code in optical fibre communication systems is not give the good bit error rate. So the decoding algorithm of LDPC code can be modified and with which the Bit error rate can be improved. It is a very powerful code for forward error correction system. This modification is beneficial for the high speed fibre optic communication systems. We present here a decoding of modified Low density parity check code using BPSK modulation which is useful in Optical fibre communication. Soft and hard decision decoding are two decoding technique useful in LDPC codes.

Keywords: Low density parity check codes (LDPC), Binary Phase shift Keying (BPSK), Bit error rate (BER), additive white Gaussian noise (AWGN).

1. INTRODUCTION

A. Basics of LDPC

The name low density comes from the characteristic of their parity-check matrix which contains low numbers of 1's in comparison to the amount of 0's. The main advantage of LDPC is that they provide a performance which is very close to the capacity for a lot of different channels and linear time complex algorithms for decoding Gallager first introduce these codes during his PhD thesis in 1960. LDPC codes are described by two ways either matrices or with graphical representation. In matrix representation, the matrix is a parity check matrix with dimension n × m for a (8, 4) code. For defining the number of 1's in each row wr is used and wc is used for the columns. For a matrix to be called low-density the two conditions wc << n and wr << m must be satisfied. For that reason the parity check matrix should usually be very large.[1]

$$\mathbf{H} = \begin{bmatrix} 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 0 & 1 & 1 & 0 & 1 & 0 \end{bmatrix}$$

Fig 1: Parity check matrix

In graphical representation, tanner graph represents the LDPC codes. Basically tanner graphs are bipartite graphs. That means that the nodes of the graph are separated into two distinctive sets and edges are only connecting nodes of two different types. Variable nodes (v-nodes) and check nodes are the two types of nodes in a Tanner graph. This code not only provide the complete representation of the code, they also help to describe the decoding algorithm.[1]

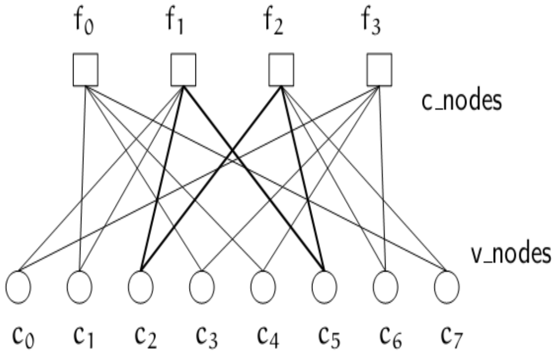

Fig 2: Tanner graph corresponding to the parity check matrix in Fig 1. The marked path c2 → f1 →c5 → f2 → c2 is an example for a short cycle. Those should usually be avoided since they are bad for decoding performance. [1]

B. Decoding of LDPC using BPSK modulation

To achieve a minimum Bit error rate (BER) at minimum signal to noise ratio BPSK modulation is use.
In this paper we have done decoding of LDPC with BPSK modulation using two different code rates ½ and ¾ and after simulation we find that ½ code rate gives less bit error rate than ¾ at different values of signal to noise ratio. We check the bit error rate at different values and find that by using code rate ½ we find the less bit error rate at 0.5 signal to noise ratio.

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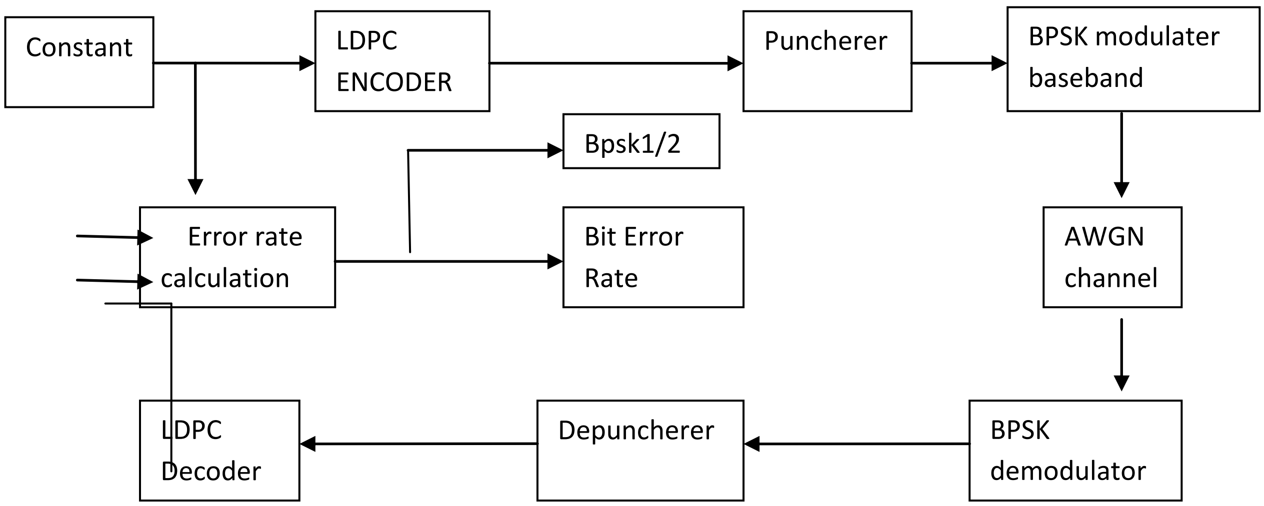

Fig: LDPC encoder and decoder using BPSK modulation

Low density parity check codes (LDPC) is a prime examples of codes on graphs. LDPC codes per-form nearly as well as earlier developed turbo codes in many channels [such as additive white noise Gaussian (AWGN) channel, binary symmetric channel and erasure channel]. The theory of codes on graphs has improved the error performance [3].
LDPC codes provide a significant system performance enhancement with respect to the FEC schemes employed in optical communication systems. In the area of error control coding during the last few years ignited by the excellent bit-error-rate (BER) performance of the turbo decoding algorithm demonstrated by Berrou et al [2]. Pearl developed the belief propagation algorithms and graphical models in the expert systems literature [2].
The belief propagation (BP) algorithm [5] provides a powerful tool for iterative decoding of LDPC codes. LDPC codes with iterative decoding based on BP achieve a remarkable error performance that is very close to the Shannon limit [6]. For that reason LDPC codes have received significant attention recently.
For decoding of LDPC codes mainly two types of algorithms are used first is hard decision decoding and second is soft decision decoding. soft decision decoding is one of the most powerful decoding methods for LDPC codes which is based on BP. Although BP decoding offers good performance, because of floating point computations it can become too complex for hardware implementation. The min-sum (MS) algorithm reduces the complexity of BP by approximating the calculation at the check nodes with a simple minimum operation [4].

The quantisation effect on the soft decoding of LDPC codes in fibre-optic communication systems is studied through simulation and the decoding performances for several quantisation resolutions are compared. It is found that low-bit quantisation may cause severe deterioration in the soft decoding performance. Also even though Q-factor fluctuation cannot be avoided in the experiment. [11]
Compared with the RS (255, 239) code with hard decoding in the present systems, soft decoding of LDPC code give better result. Unfortunately, analogue-to-digital conversion (ADC) with high quantisation resolution for soft decoding of LDPC codes is not available for 10 Gbps or higher speed fibre-optic communication systems. Several recent experiments for maximum-likelihood sequence estimation (MLSE)-based electrical dispersion compensation (EDC) use the ADCs at 10 Gbps. [11]
BP decoding algorithm offers good performance, because of floating point computations it can become too complex for hardware implementation. [4]

2. RELATED WORK:

The new simplified sum-product (SSP) decoding algorithm to improve BER performance for low-density parity-check codes. In this SSP algorithm multiplications and divisions can replace with additions and subtractions without extra computations. In addition, the proposed SSP algorithm can simplify both the $\ln[\tanh(x)]$and $\exp[\tan h^{-1}(x)]$ by using two quantization tables which can reduce tremendous computational complexity. After the simulation, results show that the proposed SSP algorithm can improve about 0.3~0.8 dB of BER performance in comparison with the existing modified sum-product algorithm. [12]

An approach is present for constructing LDPC codes without cycles of length 4 and 6. Here we design 3 sub matrices with different shifting functions, and then these sub matrices are combine into the matrix specified by the proposed approach, finally, this matrix expand into a desired parity-check matrix using identity matrices and cyclic shift matrices of the identity matrices. By simulation result of AWGN channel it is verified that the BER of the proposed code is close to those of Mackay's random codes and Tanner's QC codes.
A bipartite graph called Tanner graph describe LDPC codes, and the girth of a Tanner graph is the length of the shortest cycle in the graph. To prevent the sum-product algorithm from converging girths in the Tanner graphs of LDPC codes is use. Short cycles; degrade the performance of LDPC decoders, because they affect the independence of the extrinsic information exchanged in the iterative decoding. Hence, LDPC codes with large girth are desired. There are many possible ways to construct the LDPC codes with large girths. Due to the complicated constraints for the structures of parity-check matrices, some of the code constructions are not satisfied for application. To solve the problem, this letter provides a different construction of LDPC codes with large girth. [8]

3. FUTURE SCOPE:

Low-bit quantisation may cause severe deterioration in the decoding performance. For the improvement of the low-bit quantised soft decoding, a simple modification to the decoding algorithms is proposed. [11]
Analogue-to-digital conversion (ADC) with high quantisation resolution for soft decoding of LDPC codes is not available for 10 Gbps or higher speed fibre-optic communication systems. But the ADCs at 10 Gbps used in several recent experiments for maximum-likelihood sequence estimation (MLSE)-based electrical dispersion compensation (EDC). For that reason the original LDPC min-sum (MS) decoding algorithm can be modify and this modified algorithm can help to improve the decoding performance at low quantisation resolution. [11]
For computing the capacity of low-density parity-check (LDPC) codes under message-passing decoding density evolution algorithm is use. For memory less binary-input continuous-output additive white Gaussian noise (AWGN) channels and sum-product decoders, we use a Gaussian approximation for message densities under density evolution to simplify the analysis of the decoding algorithm. We convert the infinite-dimensional problem of iteratively calculating message densities, which is needed to find the exact threshold, to a one-dimensional problem of updating means of Gaussian densities. This simplification not only allows us to calculate the threshold quickly and to understand the behaviour of the decoder better, but also makes it easier to design good irregular LDPC codes for AWGN channels. [9]
we derived the density evolution for two improved BP-based algorithms of the LDPC decoding, i.e., the normalized and the offset BP-based algorithms. The density evolution of these two improved BP-based algorithms was studied in a practical way, with no efforts on theoretic issues such as concentration and convergence theorems. The numerical results show that both algorithms can achieve performance very close to that of the BP algorithm with properly chosen decoder parameters, and the simulation results validate it. The discretized density evolution of the BP-based algorithm has also been derived and extended to the offset BP-based algorithm. The simulations show that with uniform quantization of only 6 bits, the quantized offset BP-based algorithm has degradation less than 0.1 dB compared to the BP algorithm. [10]

CONCLUSION:

The bit error rate on the decoding of LDPC codes by using BPSK modulation system is studied through simulation and the decoding performances for code rate ½ and ¾ are compared on different signal to noise ratio. In the decoding performance it is found that by using BPSK modulation with code rate of ½ we get low bit error rate at low signal to noise ratio. After simulation we find that we get bit error rate near about zero at 0.5 signal to noise ratio. The proposed modification scheme can also be applied to the BP and the MS decoding algorithms for a better performance.
By experiment the decoding performance of LDPC code is also verified where 2-dB coding gain over RS (255, 239) code can be obtained at the same redundancy with the quasi-cyclic LDPC code. Even though Q-factor fluctuation cannot be avoided in the experiment, the experimental BER is only slightly worse than the one from the simulation. Quasi-cyclic structure of LDPC code provides a way for distributed memory storage and access of LLR information during row and column operations of the information exchange in an orderly way. The encoder and decoder implementation of such a LDPC code can more easily meet the high-speed requirement for fibre-optic communication systems.

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