DESIGN OF ENHANCED MULTI-BIT THRESHOLD BIT FLIPPING ALGORITHM FOR LOW COMPLEX LDPC DECODERS

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ABSTRACT

Communication is transfer of information from source to sink or sender to receiver. The signal when transferred through the noisy channel gets affected by the noise and becomes an error signal when it reaches the receiver. Decoding is the process of retrieving the correct information from the received signal. The weighted bit flipping LDPC decoding algorithm gives a good performance in retrieving information. The proposed algorithm which is modified multi bit threshold weighted bit flipping decoding (MMTWBF) algorithm of low density check code (LDPC) gives a good performance and an effective practicability in comparison with reliability rate weighted bit flipping algorithm (RRWBF) and good speed compared to multi-bit threshold rate based weighted bit flipping algorithm(MTRWBF). This algorithm flips the plurality of bits at each time, which helps in reducing the shortcomings in improved reliability rate weighted bit flipping algorithm (IRRWBF) decoding convergence speed. The simulation results reveal the improvement in simulation speed and the decoding iteration is reduced.

Keywords: low density parity check code (LDPC), iterative decoding, reliability rate, weighted bit-flipping (WBF).

1. INTRODUCTION

Low, density parity check (LDPC) code are forward error-correction codes first proposed by Gallager in 1962 [1], and due to its extraordinary performance it has drawn great attention in recent years and using iterative decoders its performance is near to the Shannon limit and due to this LDPC codes has found its strong impact in communication standards. Even though LDPC was introduced first before turbo codes, it didn't find its importance at that time. The turbo codes involve very little algebra, employ iterative, algorithm used is distributed algorithms, average performance and rely on soft information extracted from the channel [12]. LDPC codes are nothing but block codes with parity-check matrices (H) which has very less non-zero entries. Construction of LDPC codes are done by first creating a sparse parity-check matrix first and then after receiving the code obtaining the generator matrix.

Decoding of LDPC codes can be done using soft-decision algorithm which is message passing algorithm such as belief propagation (BP), hard-decision algorithm such as bit flipping (BF) and hybrid decoding methods [11]. In the paper a slight modification in MTRWBF algorithm is proposed called modified multi bit threshold [7] weighted bit flipping algorithm (MMTWBF).

The remainder of this paper is arranged as**:** Section II discusses on the various bit-flipping algorithm and recent reported decoding algorithms. Section III summarizes the proposed MMTWBF algorithm. Section IV explains the results and comparison with other decoding algorithm. Conclusion of the proposed algorithm is given in Section V.

2. ANALYSIS Of LDPC DECODING ALGORITHM

a) WBF algorithm

BF algorithm gives simplest algorithm for weighted bit flipping; here the weights of the bit have the information on its corresponding check equations. WBF algorithm smooth's the difference between simple BF and soft decoding. It's a simple algorithm with iterative approach In recent years, improved algorithms over weighted bit-flipping algorithm has emerged and they varies from the calculation of weights, the aim still remains fast and accurately locate the bit error. The improved algorithms over WBF are parallel WBF (PWBF) and fast PWBF (FPWBF) algorithms. The WBF algorithm uses some reliability information, which can obtain better performance than BF, especially the larger weight, such as finite geometric codes [6]. In original WBF algorithm, the decoding algorithm is split into four steps and they are initialization, check node, variable node, and decision steps [3].

b) Reliability rate weighted bit-flipping algorithm

In WBF we consider the absolute value symbols which are smallest and if any parity equation turns to be wrong that symbols have the error possibility in the equation. As the absolute value of error becomes smaller the higher is the likelihood of error. As the absolute value increase the possibility of error increases. The drawbacks in WBF algorithm is recovered in a considerable rate in RRWBF algorithm, thus introduces a new criterion called reliability ratio (RR) [2].

In RRWBF the decision for bit flipping is based on ratio of reliabilities of variable bits which are elements of the parity check equation [5].

c) Improved RRWBF algorithm

The error probability performance compared to RRWBF was improved more by using a new algorithm, improved RRWBF. In IRRWBF algorithm the weight of bit are more concise than in RRWBF and the decoding is less computationally complex [4].

VOL. 10, NO. 7, APRIL 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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d) Multi bit threshold rate based weighted bit flipping algorithm

The MTRWBF flips multiple bits by combing multi-bit flipping algorithm LCMBF and multi GDBF algorithm [11]. In WBF, RRWBF, IRRWBF algorithms only one bit is flipped each time whereas in MTRWBF multiple bits are flipped during each iteration [10] also multi-bit threshold ratio. MTRWBF uses [7] reliability ratio based bit flipping.

3. MODIFIED MULTI-BIT THRESHOLD WEIGHTED BIT FLIPPING DECODING ALGORITHM

The relationship of the likelihood ratio of the absolute value of reach output y_n of the received sequence y for associated with the hard-decision b in AWGN channel is given below.

$$\varsigma = |\ln(p(y_n|c_n = 1)/p(y_n|c_n = 0))|/|y_n| \qquad (1)$$

where ⍰is proportional factor.

In RRWBF and IRRWBF algorithms only ratio of absolute value is considered but doesn't reflect symbol information and in case of MTRWBF algorithm multiple bits are flipped according to the threshold value. The MTRWBF algorithm also considers the reliability ratio [9]. In decoding algorithms mentioned above, WBF, RRWBF and IRRWBF, only single bit is flipped. In MMTWBF algorithm multiple bits and the bits are flipped using minimum of hard decision b_n. In WBF, RRWBF, IRRWBF and MTRWBF algorithms the complexity of algorithm is high and also time consumption is high, whereas in MMTWBF algorithm the complexity of algorithm is reduced and time also with improved BER performance.

a) MMTWBF algorithm

The set Ƥ denotes the absolute value of discriminate and to denote the threshold for the magnitude of smaller symbols we use ω. The steps are as follows:

Initialization: $Ƥ = \{b_n \le \omega\}, Q_m = \min(y_n)$; (2)

Check node: $s_m = \sum_{n=1}^{N} H_{mn} b_n$; (3)

Variable node: $E_n = \frac{1}{|y_n|}\sum_{m \in M(n)} \frac{(2s_m - 1)}{Q_m}$; (4)

Decision: Flip the bit b_n for $E_{kmax} = \max(E_n)$, where bit satisfies $b_n \in \{x | Q\, E_{n\,min} \le x \le E_{n\,max}\}$ and $b_n \in \{x | x < y_n\}$.

Repeat the steps from check node to decision until all of the check equations get satisfied or till the maximum iteration is reached or else decoding fails [8].

b) Evaluation

The MMTWBF is a low complex algorithm and the bit error rate is better. The decoding algorithm proposed reduces the time taken to decode the code with less error. The Figure-1 shows the changes in performance as the iteration is increased. Here the below graph represents the performance during various iterations such as during 5th, 9th and 25th iterations. The graph shows an improvement in the BER. The proposed algorithm performance is shown in Figure-1, which shows better performance for increase in iterations.

The performance of the proposed algorithm is given as bit error rate verses signal-to-noise ratio in Figure-1. The change in performance is illustrated correctly here.

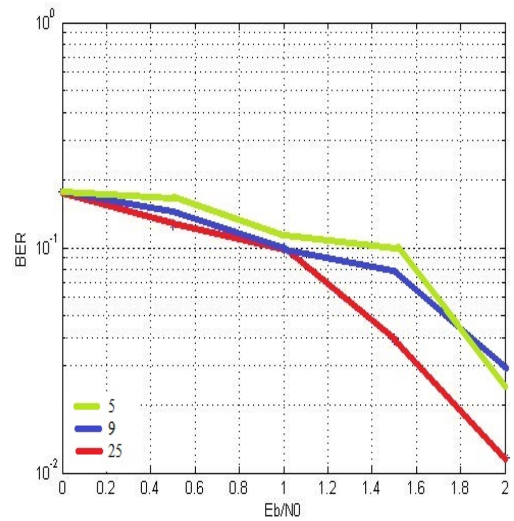

Figure-1. Improved algorithm performance for various iterations.

c) Flowchart

The flow of MMTWBF algorithm is revealed in the flowchart given in Figure-2. The proposed weighted bit flipping algorithm which is MMTWBF algorithm finds the minimum of the received and finds the threshold out of it. The MMTWBF algorithm then flips the bits according to the threshold.

The flowchart demonstrates the flow of codes in the algorithm. In MMTWBF algorithm multiple bits are flipped.

VOL. 10, NO. 7, APRIL 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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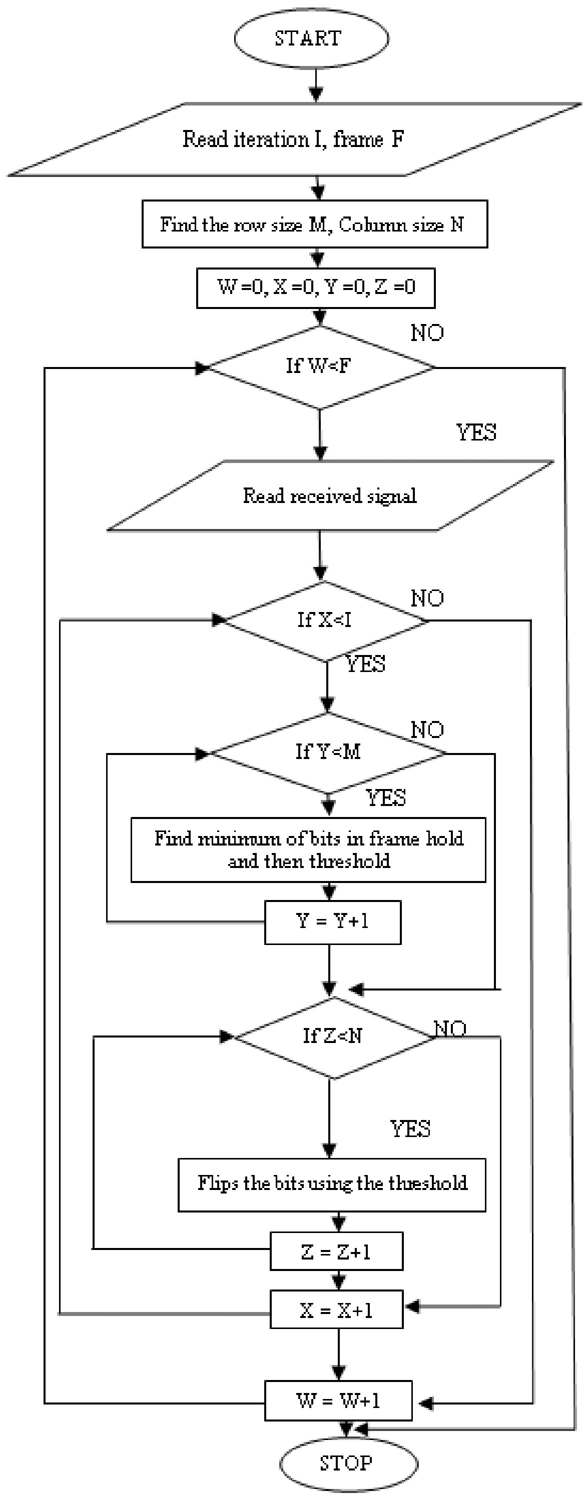

Figure-2. Flowchart of MMTWB.

4. RESULT

LDPC codes executed in Matlab with the condition that Gallager structure, which generates a random parity check matrix *H*, M = 500, N = 500 and the weight of column is 3 and BPSK modulation in assumption that the transmitted channel is additive white Gaussian noise (AWGN).

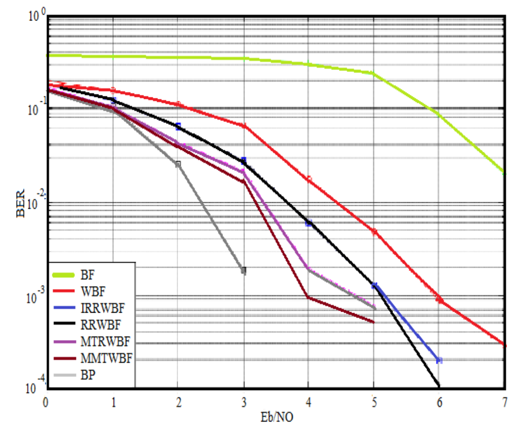

Figure-3. Comparison of performance for 10 iterations.

The comparison of proposed MMTWBF algorithm with WBF, RRWBF, IRRWBF, and MTRWBF for same iterations and with MTRWBF algorithm for same iteration is shown in Figure-2 and Figure-3, respectively. In Figure-2, BF shows a worse performance even though it is less complex and easy hardware implementation. MMTWBF algorithm has better performance between BF and BP. MMTWBF has better performance and good convergence speed than WBF, RRWBF, IRRWBF and MTRWBF algorithms.

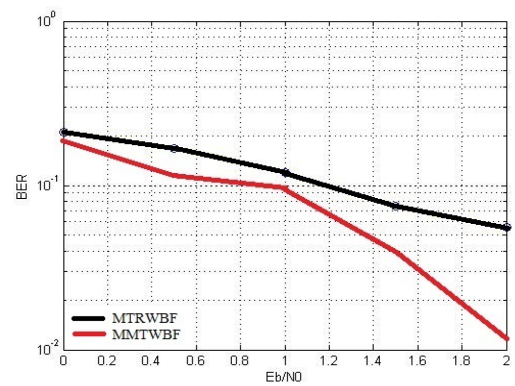

Figure-4. Comparison of performance for 25 iterations.

The proposed MMTWBF algorithm in on comparison with MTRWBF algorithm has a better bit rate and better convergence speed which is shown in Table-1 and Table-2, respectively. As the iterations are increased we get better performance. The time taken for execution of both the algorithms differs. The proposed MMTWBF algorithm gives a better convergence speed than MTRWBF.

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Table-1. Comparison of bit rate.

Iteration	MTRWBF	MMTWBF
5	0.149	0.1147
9	0.138	0.0919
20	0.125	0.0910
25	0.120	0.0901

Table-2. Comparison of time taken for execution.

Iteration	MTRWBF	MMTWBF
5	30.305	29.074
9	32.3489	31.1905
20	39.2089	35.765
25	42.422	38.958

As the iterations increases the difference in time for execution of the proposed MMTWBF algorithm with MTRWBF algorithm increases. It implies that the proposed MMTWBF algorithm has better speed of execution. The decoding is done faster.

5. CONCLUSIONS

The proposed MMTWBF algorithm flips the multiple bits according to the threshold. The threshold was selected from the minimum of each received sequence and the bits are flipped. The proposed algorithm reduces the complexity and has a better convergence speed than MTRWBF algorithm. Simulation results show the proposed MMTWBF algorithm requires less iteration and gives a better performance than MTRWBF. The performance of the proposed algorithm which is modified multi-bit threshold weighted bit flipping can be evaluated in future in various channels like binary erasure channel (BEC) and Binary symmetric channel (BSC).

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